PERCHLORATE

Perchlorate is a contaminant that exists in the environment as a part of other compounds such as ammonium, potassium, or sodium perchlorate. Ammonium perchlorate is manufactured as an oxygen-adding component in solid fuel propellant for rockets, missiles, and fireworks. The concerns surrounding perchlorate contamination involves its ability to affect the thyroid gland, which can affect metabolism, growth, and development. The Office of Ground Water and Drinking Water is co-chairing the Interagency Perchlorate Steering Committee (IPSC) to disseminate scientific information and frame policy issues regarding potential perchlorate contamination.

Insert "NEW" icon: Update on Perchlorate Issues (make this a big star-like button)

(Put these categories as individual hot buttons - we'd work on developing these, either taking parts from the discussion papers currently on the web or putting them in a question and answer format)

Background	Occurrence	IPSC
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Update on Perchlorate Issues - May 2000

Background

• The United States Environmental Protection Agency (EPA) has been working with states, federal agencies, tribes, local governments, water suppliers, and the private sector to address a potential threat to groundwater and surface water resources from perchlorate. The Interagency Perchlorate Steering Committee (IPSC) is co-chaired by the EPA and the Department of Defense, and is comprised of representatives from 23 federal, state, tribal, and local government agencies. Standing subcommittees are devoted to human health and toxicology, occurrence, ecotoxicology/transport and transformation, analytical methods, treatment technologies, and communication and outreach.

• Perchlorate is of concern because of: 1) potential human health effects at low concentrations of exposure; 2) the possibility that perchlorate may be widespread in the environment; 3) the

expense of removing perchlorate from water and soil; and 4) the effects that perchlorate may have on ecosystems. Perchlorate can inhibit iodine uptake in the thyroid gland and reduce thyroid hormone production. Thyroid hormone deficiencies can affect normal metabolism, growth, and development.

• Perchlorate typically originates as a contaminant in the environment from the solid salts of ammonium, potassium, or sodium perchlorate. The perchlorate part of the salts (ClO4-) is a combination of the elements chlorine and oxygen, and is soluble and mobile in water. Perchlorate can persist for many decades under typical groundwater and surface water conditions, because of its resistance to reaction with other available elements.

• Ammonium perchlorate is manufactured for use as the oxidizer component and primary ingredient in solid fuel for rockets (for example, the space shuttle), missiles, and fireworks. Large-scale production of ammonium perchlorate began in the United States in the mid-1940s. The solid fuel of the country's rocket and missile inventory must be periodically replaced because of the shelf life of one of its other components. Perchlorate has been disposed of since the 1940s at manufacturing, military, and other sites. Perchlorate compounds are used in the manufacture of matches and in analytical chemistry. Other uses of perchlorate salts include their use in nuclear reactors and electronic tubes, as additives in lubricating oils, as a component of air bag inflators in automobiles, in tanning and finishing leather, as a fixer for fabrics and dyes, in electroplating, in aluminum refining, in rubber manufacture, and in the production of paints and enamels.

• Chemical fertilizer has also been reported as a potential source of perchlorate contamination. The source of perchlorate in fertilizers is unknown and is being investigated. The potential for this new source to contaminate soil, to transport into water resources, or to be taken up by plants, has not yet been fully characterized. The EPA is participating with the Department of Defense, industry and private laboratories to evaluate the occurrence of perchlorate in commercial and household fertilizers. Preliminary results indicate that perchlorate levels can vary significantly between fertilizer brands and formulation types. Significant variations between different lots have been demonstrated, suggesting variations in production practices and/or perchlorate levels in the raw materials and/or lab procedures.

• Based on assessments of existing information in 1992 and revised in 1995, the EPA had established a provisional oral reference dose (RfD) range for perchlorate. The provisional oral RfD is a concentration of a chemical expressed in units of milligrams of perchlorate per kilogram of body weight per day (mg/kg-day). In general, the oral RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of detrimental effects during a lifetime. The standing provisional reference dose range is 0.0001 to 0.0005 mg/kg-day. By applying the standard default body weight (70 kilograms) and water consumption level (2 liters per day), the resulting provisional cleanup or action levels would range from 4-18 parts per billion (ppb).

• Prior to April 1997, perchlorate could not be reliably detected at concentrations below 100 ppb in water. Many uncertainties remained about its toxicity, about how to remove it from water, or how extensive a problem perchlorate might pose to water supplies. In April 1997, the California Department of Health Services (CA DHS) developed a new analytical method to detect low levels of perchlorate (4 ppb) in water.

• Within the last three years, perchlorate has been found in groundwater and surface water throughout the United States, including drinking water supplies in Arizona, California, and Nevada. The EPA has received reports of perchlorate occurrence in locations in Arkansas, Iowa, Indiana, Kansas, Maryland, Nebraska, New Mexico, New York, Pennsylvania, Texas, Utah, and West Virginia.

• The EPA is currently assessing the risks posed by perchlorate. The perchlorate risk assessment is one major activity of the Interagency Perchlorate Steering Committee, which is made up of the EPA, the Department of Defense, and a number of other federal, state, and tribal agencies. The EPA's perchlorate effort involves a number of Agency offices, including the Office of Research and Development (ORD), Office of Solid Waste and Emergency Response, the Office of Water, and EPA Regions 9, 6, and 7.

Interagency Perchlorate Steering Committee

• The EPA's work to assess the potential affects to human health and the environment from perchlorate has been greatly enhanced through collaboration with its partners in the Interagency Perchlorate Steering Committee (IPSC). The IPSC, jointly chaired by the EPA and the Department of Defense (DoD), was formed in January 1998 and now has representatives from 23 different federal, tribal, state, and local government agencies. Its purpose is to ensure an integrated approach to framing perchlorate issues and to inform and involve stakeholders about developments in the technical and regulatory arenas. Standing subcommittees are devoted to health/toxicology, occurrence, ecotoxicology/transport and transformation, analytical methods, treatment technologies, occurrence and communication.

• The members of the IPSC, as of April 2000 include: United States Environmental Protection Agency, Department of Defense, National Institute for Environmental Health Sciences, National Aeronautics and Space Administration, Bureau of Indian Affairs, National Park Service, National Oceanic and Atmospheric Administration, U.S. Department of Agriculture, U.S. Food and Drug Administration, U.S. Geological Survey, Arizona Department of Environmental Quality, Arizona Department of Health Services, California Department of Health Services, Nevada Division of Environmental Protection, Texas Natural Resources Conservation Commission, Utah Department of Environmental Quality, Utah Department of Health Laboratories, Cocopah Indian Tribe, Colorado River Indian Tribes, Ft. Mojave Indian Tribe, Chemehuevi Indian Tribe, Quechan Indian Tribe, City of Santa Clarita, California.

Toxicology and Ecotoxicology Assessment Schedule

• The EPA's National Center for Environmental Assessment (NCEA) released an external review draft (ERD) of an assessment entitled *Perchlorate Environmental Contamination: Toxicological Review and Risk Characterization Based on Emerging Information* in December 1998. This ERD was reviewed at an external peer review workshop held in February 1999.

• The ERD proposed an updated human health risk assessment as well as a screening-level ecological assessment on newly performed studies on the toxicity of perchlorate. The proposed revised human oral health risk benchmark harmonized noncancer and cancer approaches to derive a single oral risk benchmark ("RfD") based on precursor effects for both neurodevelopmental effects and thyroid neoplasia.

• The external peer panel endorsed the approach but recommended to the EPA that additional human health and ecological studies be conducted to complete the assessment of perchlorate. The prioritized remaining studies are expected to be completed by DoD or the Perchlorate Study Group (a consortium of defense contractors and manufacturers) in June 2000. The EPA will then issue its new assessment for another external peer review in the Fall of 2000.

• Because of remaining significant concerns and uncertainties that must be addressed in order to finalize a human health oral risk benchmark, the EPA Office of Research and Development (ORD) has recommended that the Agency's risk assessors and risk managers continue to use the standing provisional RfD range of 0.0001 to 0.0005 mg/kg-day for perchlorate-related assessment activities.

• Protocols for studies on bioaccumulation, a study of whether perchlorate is in various crops and commodities potentially exposed to perchlorate via irrigation or fertilizer, and site-specific analyses of sites known to be affected by perchlorate are underway in a collaborative effort between DoD and the EPA. Definitive characterization of the different soil factors, types of plants and growth conditions that eaffect uptake and the potential for accumulation are part of these studies.

• Regardless of the potential source of human exposure, either directly in drinking water or by ingestion of affected food crops, the RfD estimate would be used to evaluate the potential toxicity. Evaluations of this nature need to address the uncertainties due to variability in the concentrations of the exposure sources of which there are many. ~~and these are considerable~~. The relative contribution from these potential different sources (water, food) will be evaluated in the new assessment.

• The DoD and the Perchlorate Study Group have funded the majority of the toxicological and ecological studies. Protocols for studies are reviewed in a collaborative effort by DoD and EPA scientists, as well as other external reviewers. The EPA scientists then conduct independent data analysis and interpretation for the assessment. Together the protocols, data, and the assessment are the subject of external peer review.

Analytical Methods to Detect Perchlorate

• An interlaboratory validation study of ion chromatography (IC) methods to detect perchlorate in water was released by the IPSC in April 1999. The current limit of detection for this method is 4 ppb. The EPA evaluated three different IC columns (AS-5, AS-11, and AS-16) to ascertain the effect of interferences, leading to development of a new method (EPA Method 314.0) that will serve as the basis for detection in future monitoring.

• Other analytical techniques include Raman spectroscopy and capillary electrophoresis. Development and validation of these methods will be useful to characterizing perchlorate in soils or plants and animal tissues so that transport and transformation studies can be done to track and characterize perchlorate contamination in various media.

• EPA Method 314.0 [hotlink: http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=2000_register&docid=00-4761-filed.pdf] for the analysis of perchlorate was published in the Federal Register as a direct final rule on March 2, 2000, as an approved method for monitoring under the Unregulated Contaminant Monitoring Rule (UCMR). Under the UCMR, all large public water systems and a representative sample of small public water systems will be required to monitor for perchlorate beginning in January 2001. Additional information about the UCMR is available at the following web site:
http://www.epa.gov/safewater/ucmr.html

Perchlorate in Fertilizer and Soil

• Perchlorate contamination has been thought to occur principally from the manufacture and use of perchlorate in solid rocket propellant and other pyrotechnics. The source of perchlorate in fertilizers is unknown and ~~is~~ being investigated. The potential for this new source to contaminate soil or to transport into water resources has not yet been characterized.

• Various perchlorate research projects are being conducted by the EPA and others. As part of the research, scientists at ORD's National Exposure Research Laboratory (NERL) in Athens, GA, have investigated the content of perchlorate in some commercial fertilizers. Nine brands tested each contained detectable levels of perchlorate. A communication highlighting these findings was accepted for publication in the October 1999 edition of the journal *Environmental Science & Technology (ES&T)* and was published on the journal's website. The Fertilizer Institute has raised technical concerns about ORD's findings reported in *ES&T*. ORD is exchanging scientific information with the Fertilizer Institute and other parties to shed light on the occurrence of perchlorate in fertilizers.

• The EPA is participating with DoD, industry and private laboratories to evaluate the occurrence of perchlorate in commercial and household fertilizers. Preliminary results indicate that perchlorate levels can vary significantly between fertilizer brands and formulation types. Significant variations between different lots have been demonstrated, and this suggests either

variations in production practices or perchlorate levels in the raw materials. Characterization of these variabilities and of methodological differences across the participating laboratories is not complete. A final report of the study will be available from the Air Force Research Laboratory in May 2000.

• The EPA's National Exposure Research Laboratory (NERL) has constructed preliminary studies suggesting uptake in vegetation from fertilizer containing perchlorate. These studies show that leafy garden crops, lettuce (Lactuca sativa) and mustard (Brassica alba), uptake perchlorate and its transformation products in their leaves, stems, and roots. Final results were equivocal and additional experimental work is needed to confirm these preliminary findings. Additional studies are also required to determine if accumulation occurs, under what soil and growth conditions, and in what types of plants or animals.

• NERL also examined if soil type affects adsorption (binding) of perchlorate and found that organic rich soils adsorbed significantly higher amounts of perchlorate as compared to sandy soils. The adsorption was strongly influenced by pH and concentration of perchlorate.

Uptake of Perchlorate by Plants

• Another of the EPA's research activities is to investigate methods to remove perchlorate contamination. One method under study is phytoremediation – the use of plants to degrade or take up contaminants. As part of the research, ORD/NERL scientists have investigated different kinds of plants and found that their effects vary. The objectives of these studies were to: identify what types of plants will uptake perchlorate in water, understand where in the plant perchlorate is found after uptake (i.e. in roots, leaves etc.), and whether or not perchlorate would remain in plants over a limited amount of time. These factors are important to understanding if plants could be used in treatment of soil, groundwater or surface water containing perchlorate.

• In one study lettuce seedlings were grown over approximately 24 days in water only (hydroponic) containing a range of concentrations of perchlorate. These individual experiments suggest that perchlorate can bioaccumulate by a factor of approximately 350 in the leaves. These initial results should not be extrapolated to actual farm growing conditions, or to other crop species because the experimental designs were preliminary and limited. The different conditions that might ~~e~~affect uptake and potential accumulation such as the variability in the fertilizer content, different types of soil, growth conditions and types of plants have not been characterized.

• Preliminary studies in the laboratory and greenhouse suggest that some plants break down perchlorate (directly or ~~by~~ through spurring degradation by soil microbes), while others – such as leaf lettuce and mustard – can take up perchlorate and accumulate it for a period of time in their leaves, stems, and roots.

• Additional experimental work is needed to confirm these preliminary findings. Further studies also are needed to understand the conditions under which accumulation may occur, determine

what crops might be affected, and to improve methods for measuring perchlorate. Whether agricultural plants grown under typical field conditions accumulate perchlorate from fertilizers or irrigation water is not yet known. Studies of crops leaving a typical field after a growing season and analyses of specific contaminated sites to evaluate transport and transformation of perchlorate in different soil types are to take place in early 2000.

• At this time, ORD believes that the fertilizer and plant-uptake studies are too preliminary to evaluate what risks, if any, perchlorate in fertilizers or plants pose to the public. Whether agricultural plants grown under typical field conditions accumulate perchlorate from fertilizers or irrigation water is not yet known. Crop studies and analysis of specific sites contaminated by perchlorate to evaluate transport and transformation of perchlorate in different soil types are in development. At this time, the EPA believes that it is too early to evaluate what risks, if any, exist from a food exposure route. The EPA and the United States Department of Agriculture are cooperating to rigorously investigate the potential for perchlorate entering food sources. This possible exposure route will be incorporated into the revised perchlorate risk assessment.

Treatment Technologies

• Since 1997, much progress has been made in developing treatment methods capable of removing perchlorate from water. Most of the attention has been directed at biological and ion exchange treatment technologies.

• In the biological treatment process, microbes destroy perchlorate by converting the perchlorate ion to oxygen and chloride. A six month pilot-scale study of a biological process has been completed for the San Gabriel Valley Superfund Site Baldwin Park Operable Unit in southern CA, demonstrating the reduction of perchlorate from approximately 75 ppb to below detectable levels. This system is currently in phase two testing which will run through the Summer of 2000. Based on the results of the phase two testing, a system would be constructed in the San Gabriel Valley in the Fall 2001, beginning operation in late 2001. The same process is being used in a full-scale system at the Aerojet Superfund Site in Rancho Cordova, CA, where perchlorate concentrations exceed 1,000ppb.

• In the ion exchange treatment process, the perchlorate ion is replaced by chloride, a chemically similar but nontoxic ion. Ion exchange processes have been used in homes and businesses for water softening for decades. Bench-scale and pilot-scale studies have demonstrated that ion exchange systems can reliably reduce perchlorate concentrations in San Gabriel Valley groundwater from approximately 75ppb to below detectable levels. A 2500 gallons per minute (gpm) ion exchange system is expected to begin operation in Spring 2000, producing potable water for use in the San Gabriel Valley.

• In the next year, the results of perchlorate treatment research funded by a $2 million Federal appropriation to the American Water Works Research Foundation (AWWARF) will be available. AWWARF is funding studies into biological treatment methods, ion exchange, reverse osmosis, nanofiltration, and other processes. DoD has committed $9 million in funding over three years for continued studies in perchlorate treatment technologies.

• The "best" technology for removal of perchlorate will probably vary from site to site. The results from recent and ongoing treatment technologies studies will be of use to water utilities in need of reliable, easy-to-operate treatment methods that can reliably reduce perchlorate concentrations to low or non-detectable levels, and in the remediation of non-potable contaminated groundwater.

Monitoring and Regulatory Activities

• The EPA will continue to collect information about perchlorate occurrence from its regional offices, water suppliers, IPSC member agencies, and others. This information is critical to understanding if and where exposures to perchlorate are taking place in the United States. The EPA is also coordinating efforts with DoD and State environmental offices to determine the extent of perchlorate use and potential releases at Federal facilities. The IPSC has named a subcommittee devoted to characterizing occurrence.

• Both the EPA and the United States Department of Agriculture (USDA) are interacting on ensuring that the potential for contaminated food sources is being investigated. The USDA has joined the IPSC and will be helping to steer future activities. The DoD, the EPA and USDA will collaborate on the protocols to evaluate the potential source contribution from the food supply.

• There is currently no federal National Primary Drinking Water regulation for perchlorate. It is on the EPA's Safe Drinking Water Act's Contaminant Candidate List, a list of contaminants the EPA is considering for possible new drinking water standards by 2003. Before a regulatory determination for perchlorate can be made, data gaps must be filled regarding occurrence, health effects, treatment technologies, and analytical methods.

• Beginning in 2001, all large water systems and many smaller water systems nationwide will monitor for perchlorate as required by the Unregulated Contaminant Monitoring Rule (UCMR) of the Safe Drinking Water Act. The occurrence data generated by the new UCMR will be used to evaluate and prioritize contaminants, including perchlorate, on the Contaminant Candidate List.

• The EPA's Office of Water (OW) ~~will continue to acquire data from implementation of the UCMR to make determinations of the source contribution from water. The OW~~ and the United States Geological Survey (USGS) are developing some surveys in collaboration with the IPSC. The American Water Works Association Research Foundation (AWWARF) has also conducted a survey and results are expected in the Spring of 2000.

• In 1997, California established an action level of 18 ppb for perchlorate in public water supplies. Legislative action to establish a state drinking water standard for perchlorate was passed in 1998 (California Senate Bill 1033) but was vetoed by the governor. In January 1999, CA DHS adopted a regulation identifying perchlorate as an unregulated chemical for which monitoring is required. Certain drinking water systems are required to sample their drinking

water sources for perchlorate. Additional information is available on the CA DHS web site, at http://www.dhs.cahwnet.gov/ps/ddwem/chemicals/perchl/perchl_overview.htm

• In March 1999, the Arizona Department of Health Services (ADHS) set a provisional Health Based Guidance Level of 31 pbb for perchlorate.

• In August 1999, the Texas Natural Resource Conservation Commission (TNRCC) decided to use 22 ppb as an "interim" action level for perchlorate in drinking water. In February 2000, the TNRCC proposed a surface water quality standard of 22 ppb for perchlorate in Texas. A surface water quality standard would be used by the TNRCC when issuing wastewater discharge permits under its Texas Pollutant Discharge Elimination System (TPDES). This value was calculated for a child weighing 15kg and drinking 0.64 liters/day of water over a period of 6 years.

• Following the establishment of a final harmonized oral human health risk benchmark for perchlorate, the EPA will develop a drinking water Health Advisory. The EPA will issue its new assessment for another external peer review in the Fall of 2000.

• Based on the current proposed revised oral risk benchmark for perchlorate, and standard adult default body weight (70 kilograms) and water consumption (2 liters per day) values, a drinking water equivalent level (DWEL) would be calculated at 31.5 ppb. Based on the current proposed revised oral risk benchmark for perchlorate, and standard child and newborn default body weight and water consumption values, a DWEL would be calculated at 10ppb and 5-6ppb, respectively. It is important to recognize that a DWEL is a level that assumes all exposure comes from drinking water. The EPA will consider the contribution of exposure from other sources in developing a drinking water Health Advisory for perchlorate.

SEPARATE LINK

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